AFE 76s2 Report
Derivation of Radar Altimeter Interference Tolerance Masks

Volume I: Introduction, Test Procedures, and Fundamental Test Results

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3.3 Usage Category 2

3.3.1 200 Feet AGL

3.3.1.1 Summary

Table 3-23: UC2 200' AGL Test Conditions

Source	Rationale	Signal Type	Characteristics	Setting
VSG	5G Fundamental OOBI	OFDM	100 MHz TM1.1 centered at 3750 MHz, 3850 MHz, 3930 MHz	Power Sweep
VCOs 1-2	Own-ship multiplex installation	FMCW	CF: 4300 MHz BW/Sweep Rate per AUT	ON*
VCOs 3-16	WCLS – other aircraft	FMCW	CF: 4300 MHz BW/Sweep Rate per Table 2-4	ON

* – For altimeters capable of multiplex operation. Altimeters I and V had VCO's 1-2 turned off.

Table 3-24: UC2 200' AGL OOB Fundamental Emissions Break Points

	200 ft, VCOs On (WCLS)											
	3750 MHz				3850 MHz				3930 MHz			
Altimeter	ME	1%	99%	NCD	ME	1%	99%	NCD	ME	1%	99%	NCD
A	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
I	-31 dBm	-31 dBm	-31 dBm	-30 dBm*	-32 dBm	-52 dBm	-51 dBm	-50 dBm*	-25 dBm	-35 dBm	-35 dBm	-32 dBm*
S	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
V	-50 dBm	NB	-44 dBm	-41 dBm	-40 dBm	-39 dBm	-35 dBm	-34 dBm	-42 dBm	-35 dBm	-38 dBm	-36 dBm
ITM	-56 dBm				-56 dBm				-48 dBm			
PSD	-76 dBm/MHz				-76 dBm/MHz				-68 dBm/MHz			

* – Indicates engineering judgement was applied to determine break point

3.3.1.2 Altimeter A

Table 3-25: UC2 RA-A 200' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-117	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-118	No break observed.
3850 MHz	Time History Figure 3-119	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-120	No break observed.
3930 MHz	Time History Figure 3-121	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-122	No break observed.

Center Frequency = 3750 MHz

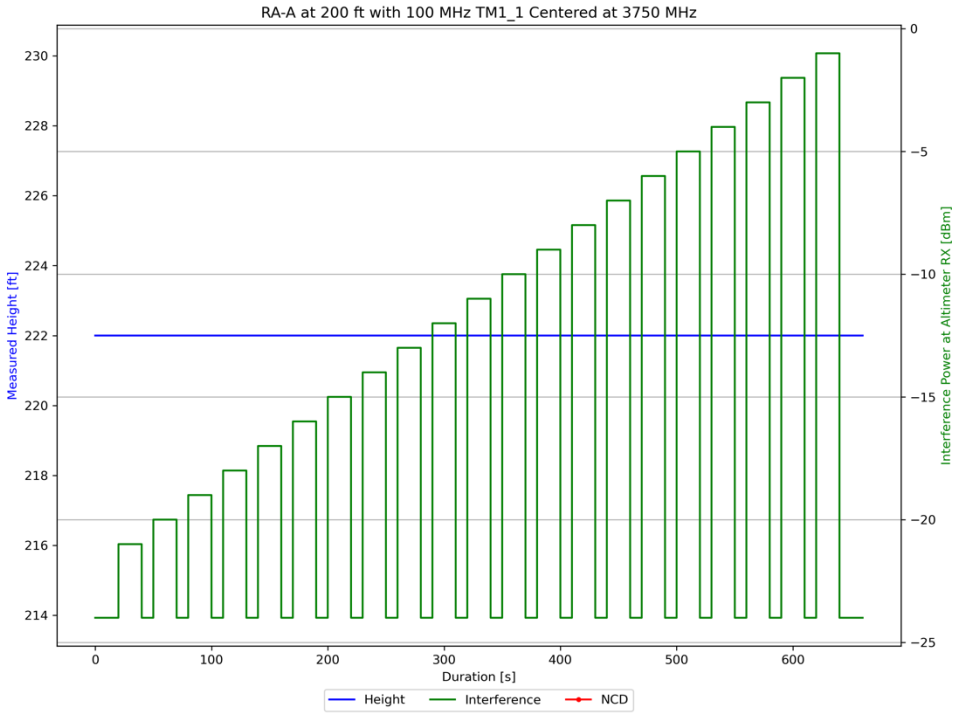

Figure 3-117: UC2 RA-A 200' AGL Time History with TM1.1 at 3750 MHz

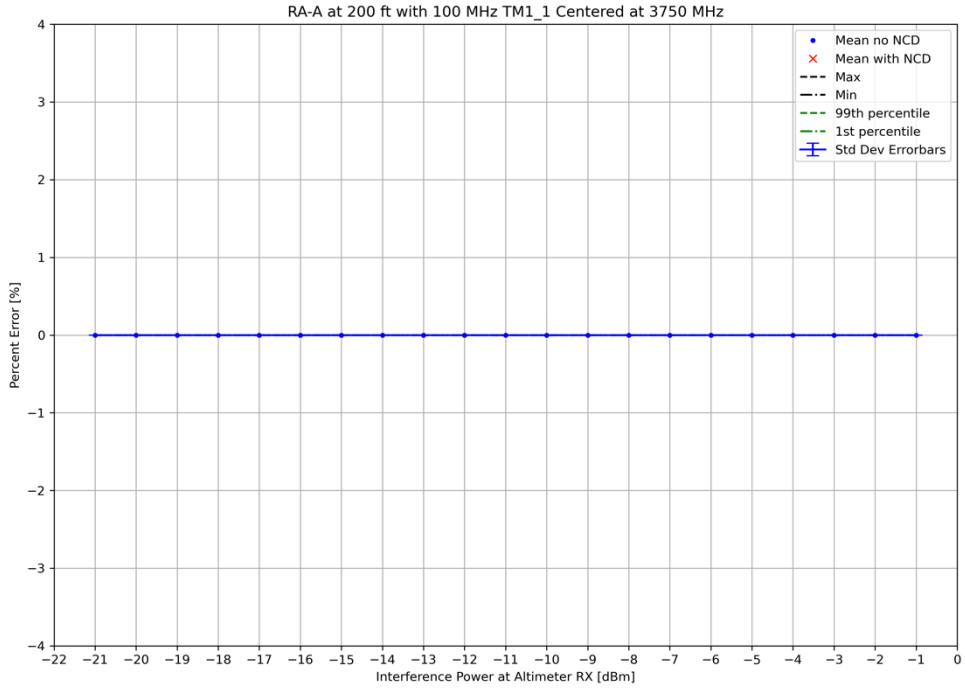

Figure 3-118: UC2 RA-A 200' AGL Statistics with TM1.1 at 3750 MHz

Center Frequency = 3850 MHz

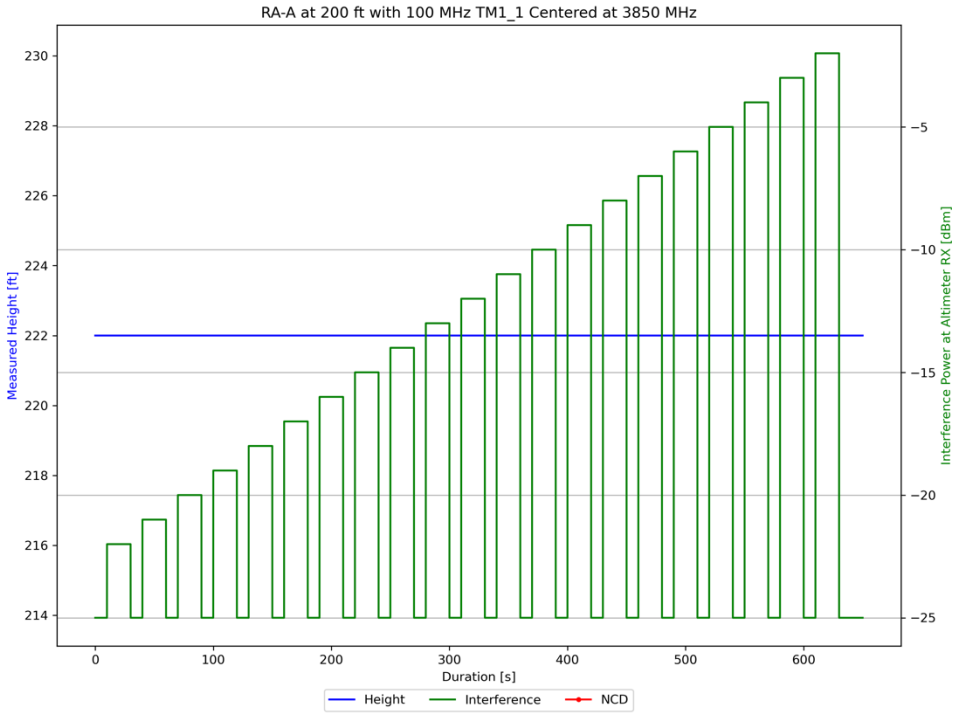

Figure 3-119: UC2 RA-A 200' AGL Time History with TM1.1 at 3850 MHz

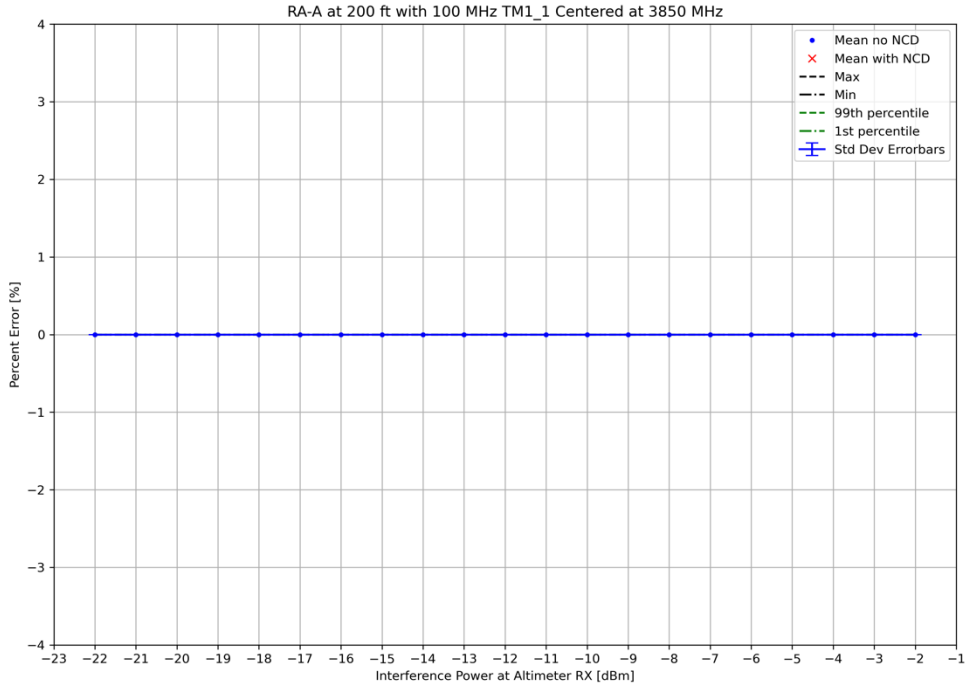

Figure 3-120: UC2 RA-A 200' AGL Statistics with TM1.1 at 3850 MHz

Center Frequency = 3930 MHz

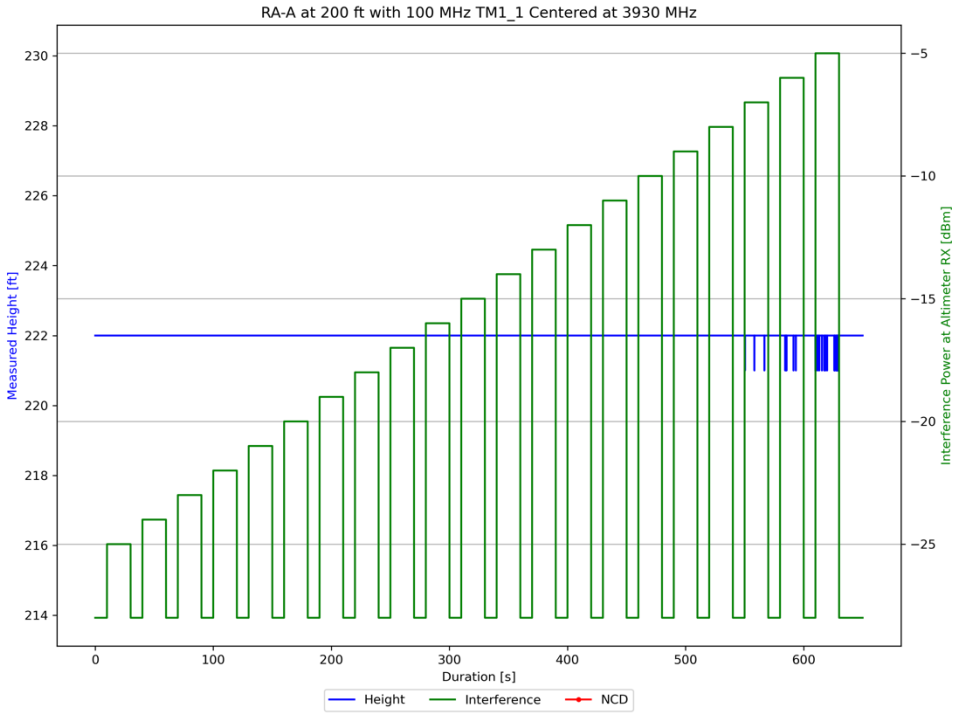

Figure 3-121: UC2 RA-A 200' AGL Time History with TM1.1 at 3930 MHz

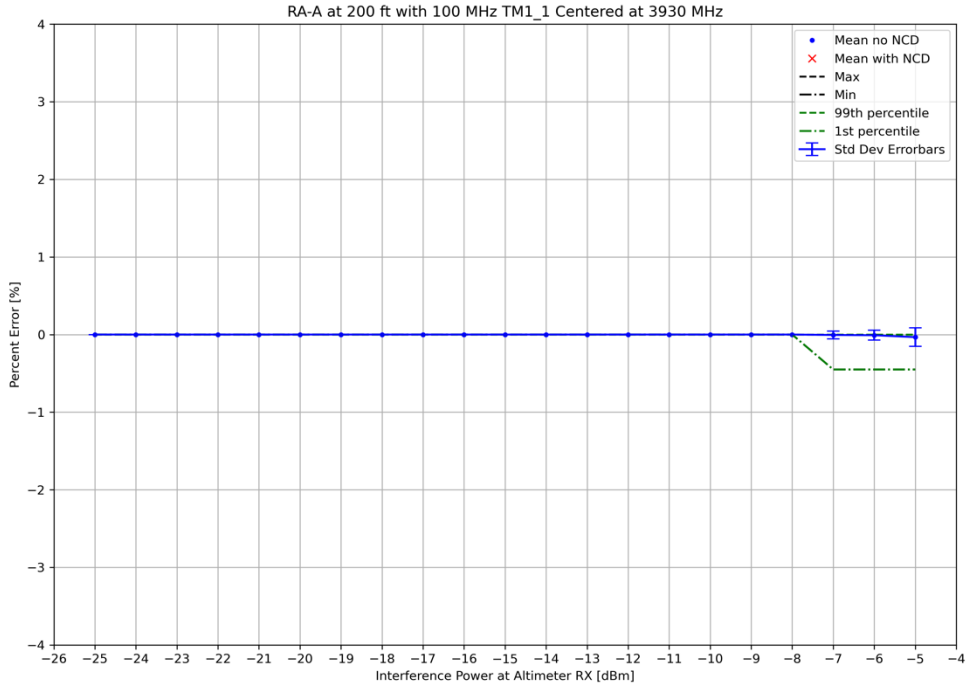

Figure 3-122: UC2 RA-A 200' AGL Statistics with TM1.1 at 3930 MHz

3.3.1.3 Altimeter I

For Altimeter I at 200 feet AGL, valid measured heights appear to be rounded to the nearest 5 feet. Subject matter experts agreed it was necessary to apply engineering judgement to take this height quantization into account when determining the break points.

Table 3-26: UC2 RA-I 200' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-123	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-124 Figure 3-125	Both the time history plot (Figure 3-123) and the zoomed out statistical plot (Figure 3-124) show degraded performance for interference powers greater than -31 dBm. Figure 3-125 indicates that the absolute mean error is more than 0.5% and the 1% and 99% percentile heights exceed the ±2% threshold at -31 dBm, and that an NCD occurs at -30 dBm. Given that the mean error reaches approximately 700% for interference powers greater than -19 dBm, and that the RA output height quantization is greater than 0.5% at 200 feet, subject matter experts applied engineering judgement to identify -30 dBm as the effective break point for this power sweep.
3850 MHz	Time History Figure 3-126	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-127 Figure 3-128	The error bars on the mean error trace on statistical plots illustrate the standard deviation of the reported height for the specific interference power step, so larger bars indicate noisy operation of the altimeter. The error bars in the zoomed-in statistics plot (Figure 3-128) indicate that the reported height standard deviation is more the 1.5% for interference powers greater that -52 dBm, though the time history plot (Figure 3-126) shows that the altimeter is still fairly well behaved for higher powers. However, the break point is set by the NCD that occurred at -50 dBm.
3930 MHz	Time History Figure 3-129	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-130 Figure 3-131	Figure 3-131 shows that the altimeter behavior with a 100 MHz interference signal centered at 3930 MHz is qualitatively similar to that shown in Figure 3-128 for 3850 MHz for interference powers less than -26 dBm. In this case, the break point is set by the NCD that occurred at -32 dBm.

Center Frequency = 3750 MHz

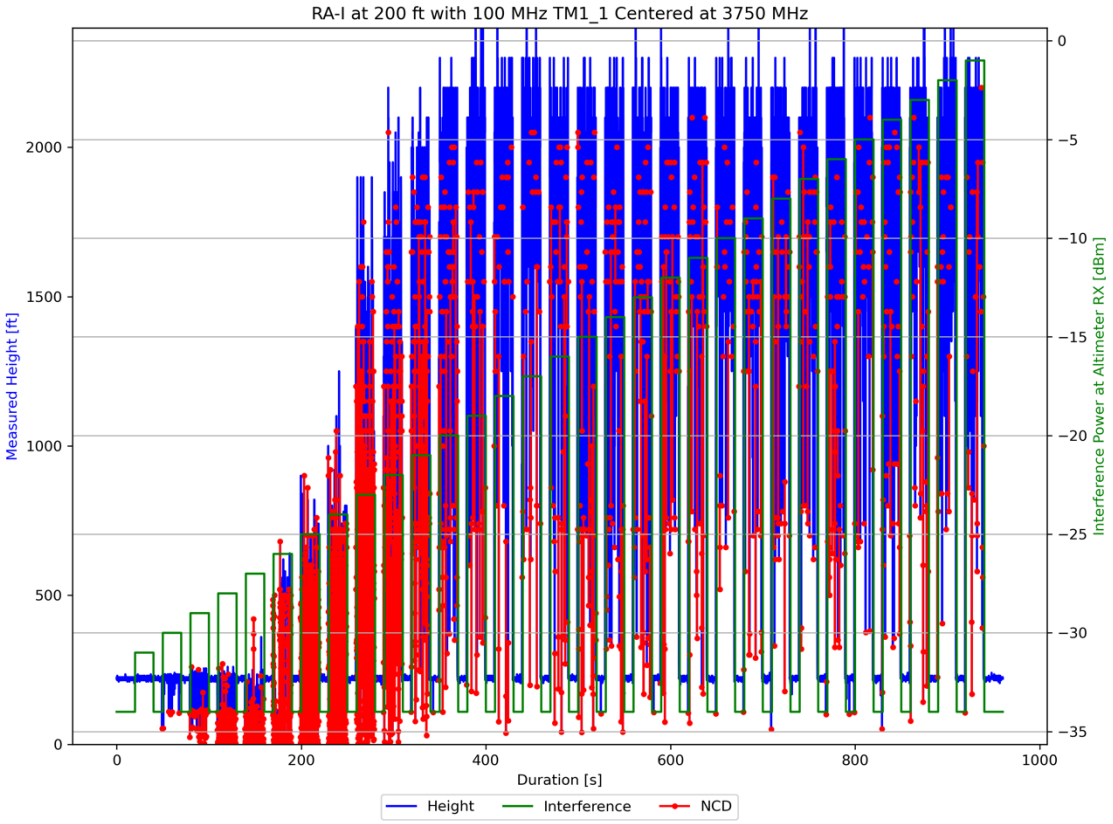

Figure 3-123: UC2 RA-I 200' AGL Time History with TM1.1 at 3750 MHz

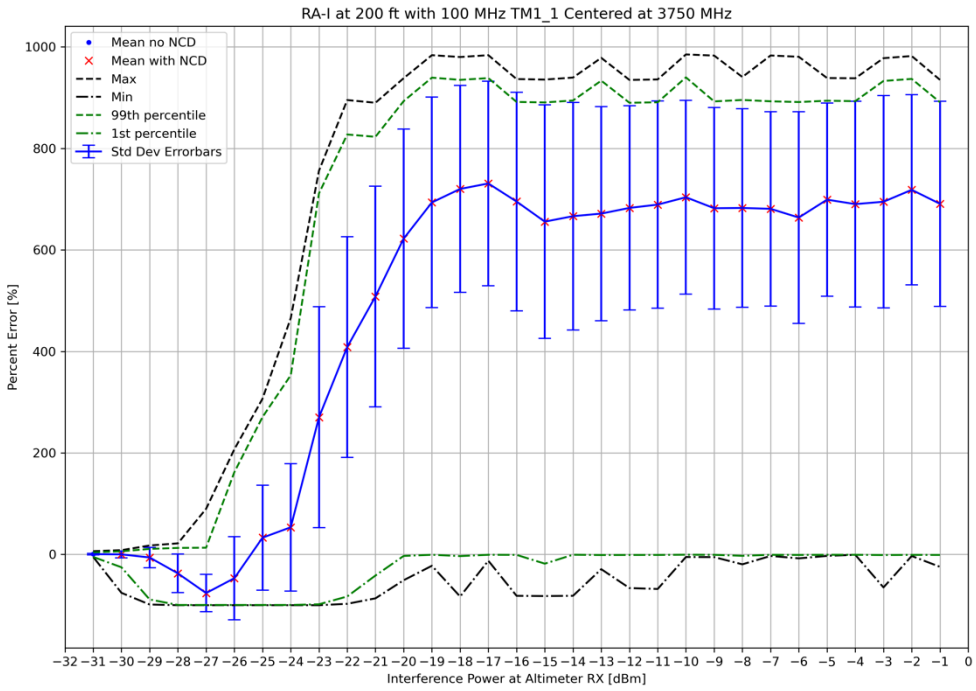

Figure 3-124: UC2 RA-I 200' AGL Statistics with TM1.1 at 3750 MHz – Zoomed Out

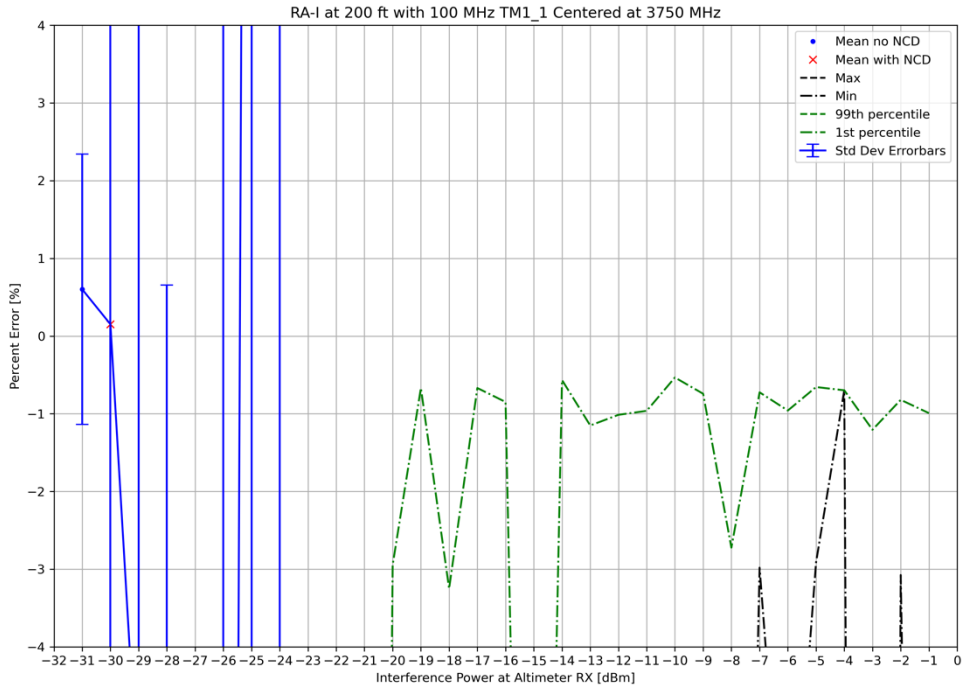

Figure 3-125: UC2 RA-I 200' AGL Statistics with TM1.1 at 3750 MHz – Zoomed In

Center Frequency = 3850 MHz

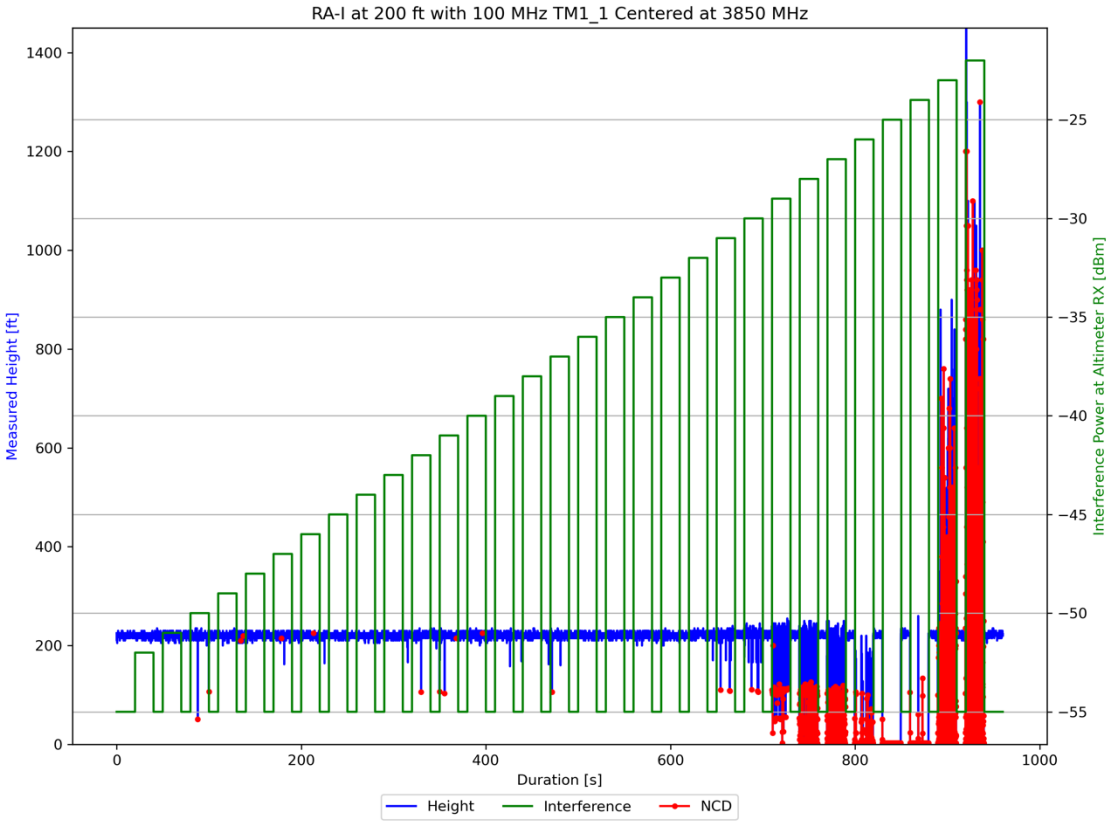

Figure 3-126: UC2 RA-I 200' AGL Time History with TM1.1 at 3850 MHz

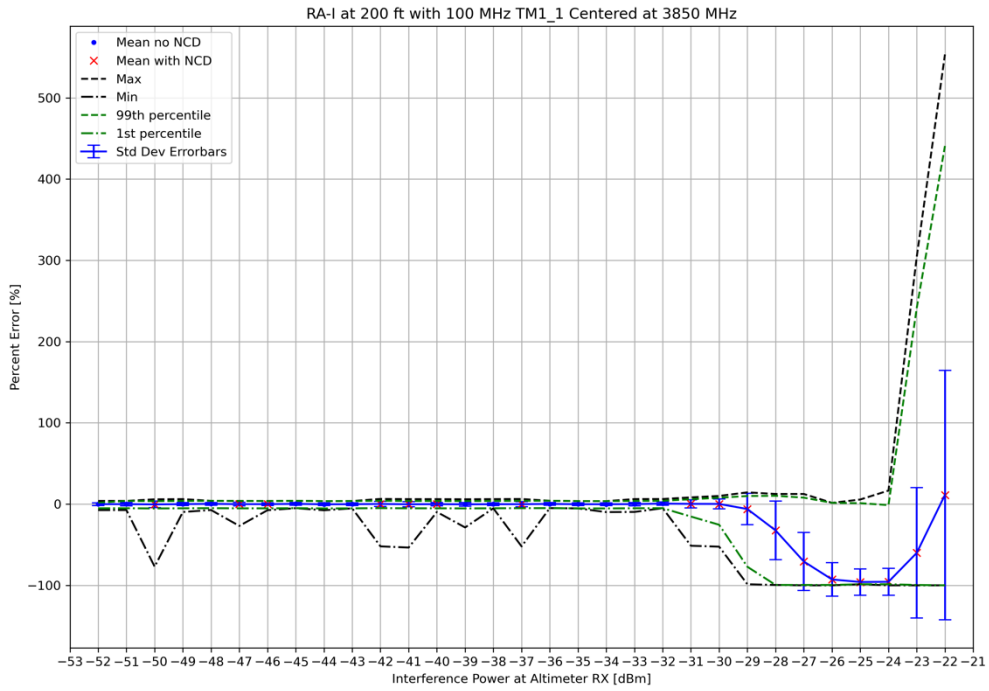

Figure 3-127: UC2 RA-I 200' AGL Statistics with TM1.1 at 3850 MHz – Zoomed Out

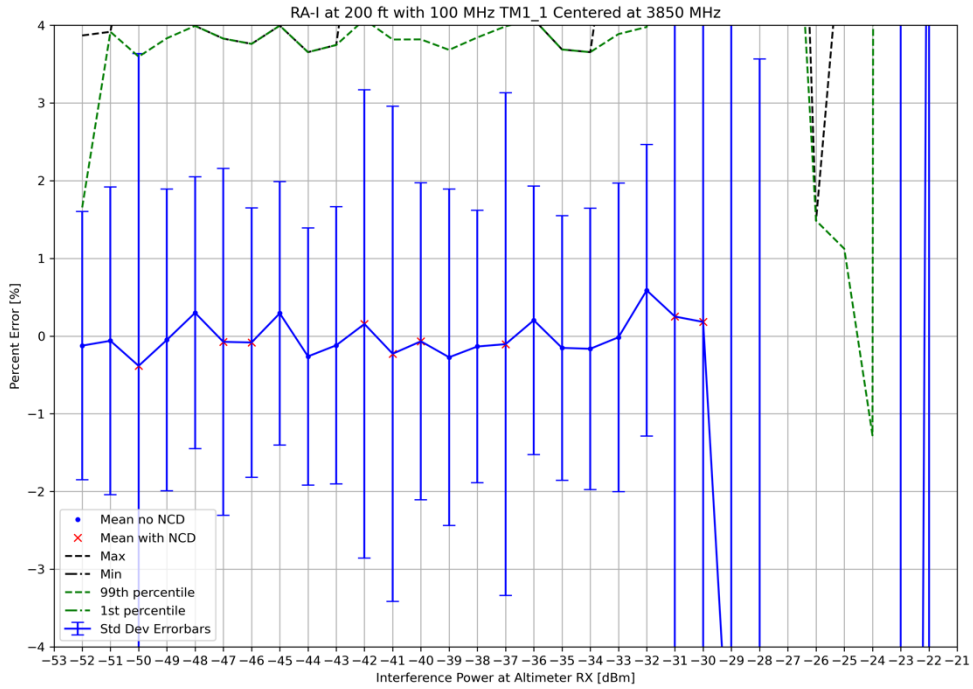

Figure 3-128: UC2 RA-I 200' AGL Statistics with TM1.1 at 3850 MHz – Zoomed In

Center Frequency = 3930 MHz

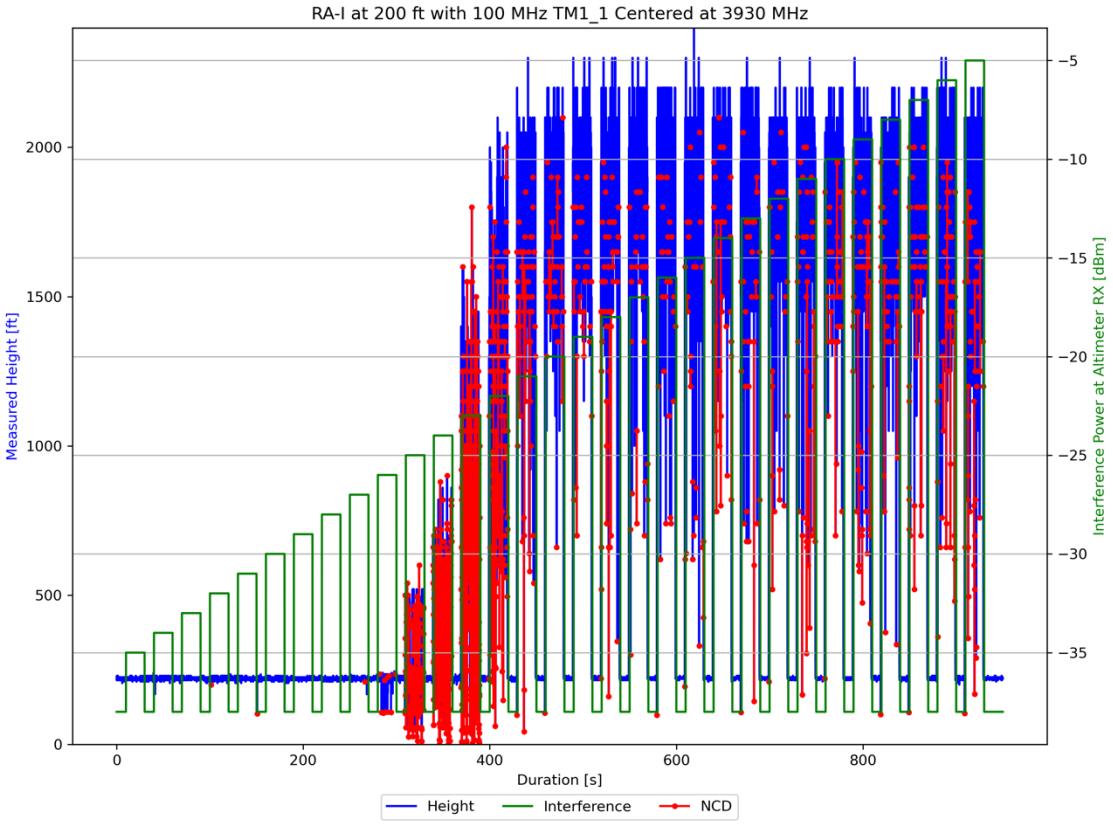

Figure 3-129: UC2 RA-I 200' AGL Time History with TM1.1 at 3930 MHz

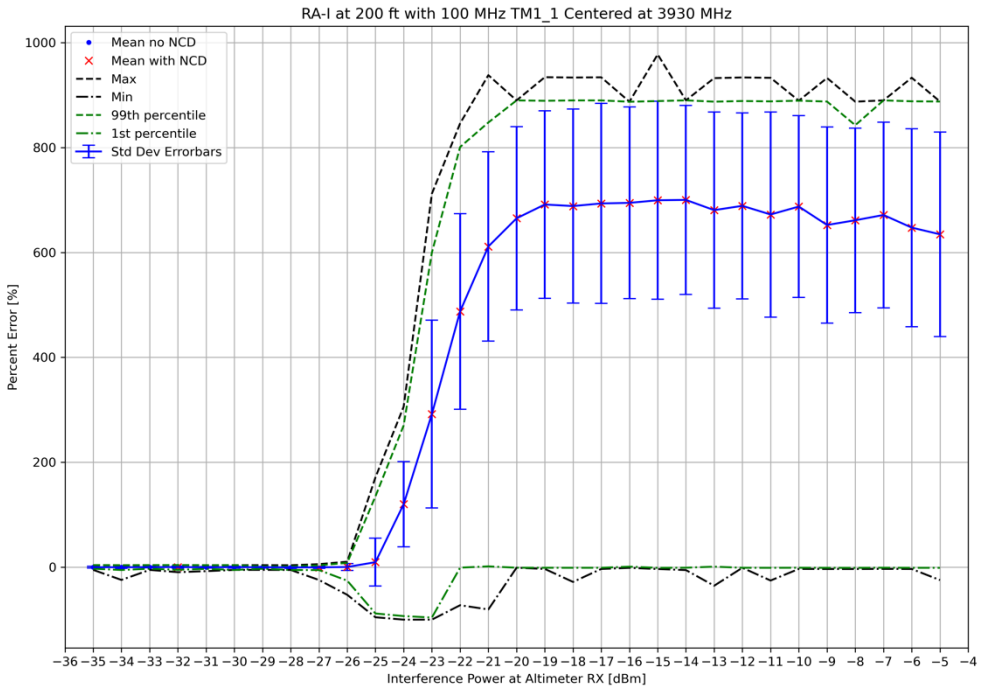

Figure 3-130: UC2 RA-I 200' AGL Statistics with TM1.1 at 3930 MHz – Zoomed Out

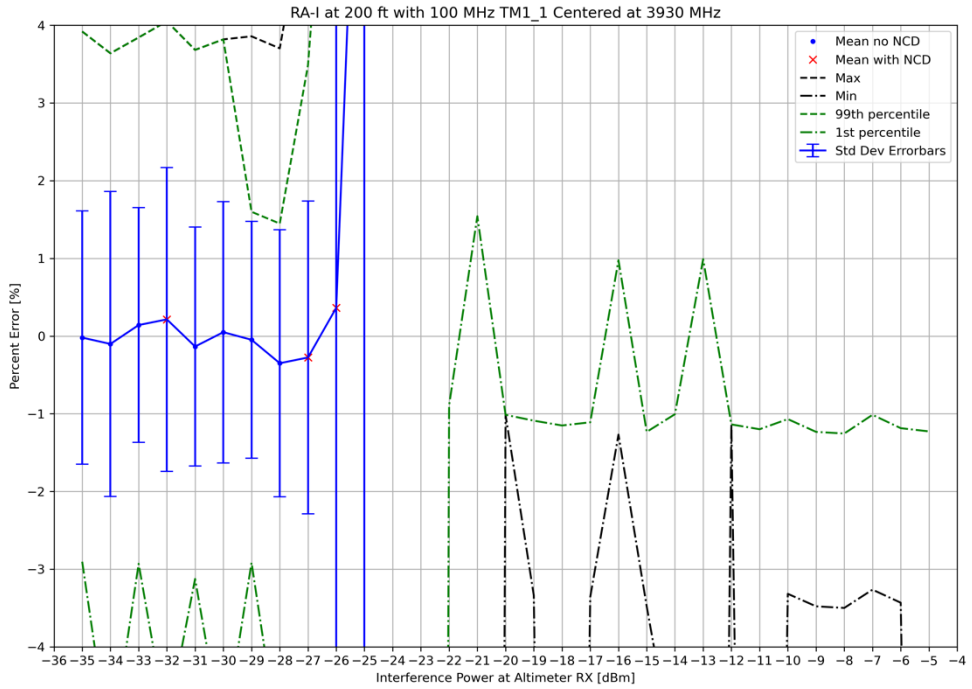

Figure 3-131: UC2 RA-I 200' AGL Statistics with TM1.1 at 3930 MHz – Zoomed In

3.3.1.4 Altimeter S

Table 3-27: UC2 RA-S 200' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-132	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-133	No break observed.
3850 MHz	Time History Figure 3-134	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-135	No break observed.
3930 MHz	Time History Figure 3-136	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-137	No break observed.

Center Frequency = 3750 MHz

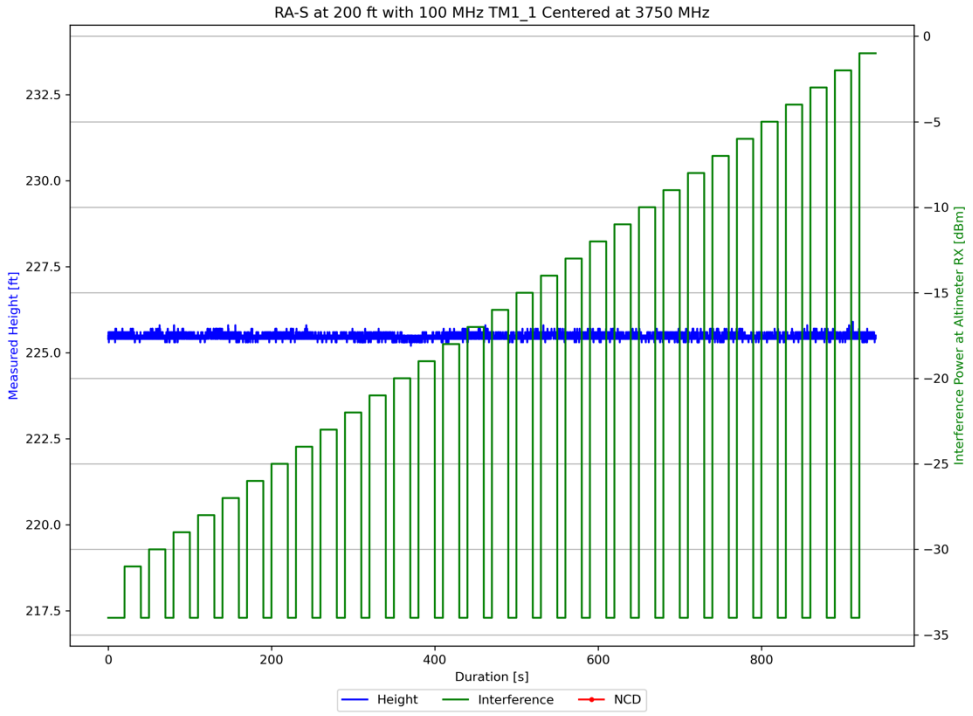

Figure 3-132: UC2 RA-S 200' AGL Time History with TM1.1 at 3750 MHz

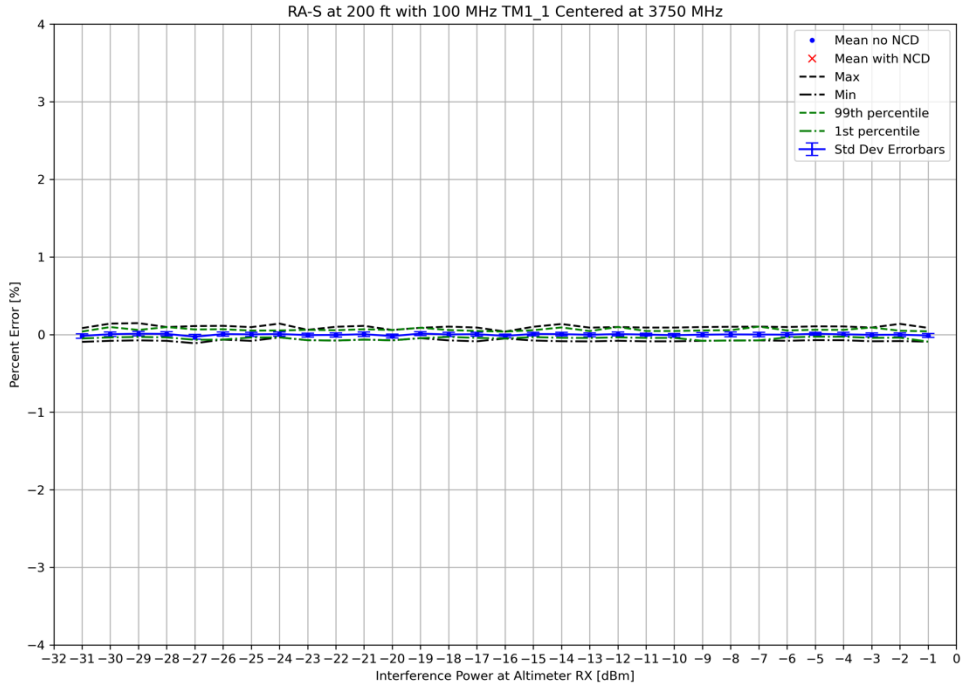

Figure 3-133: UC2 RA-S 200' AGL Statistics with TM1.1 at 3750 MHz

Center Frequency = 3850 MHz

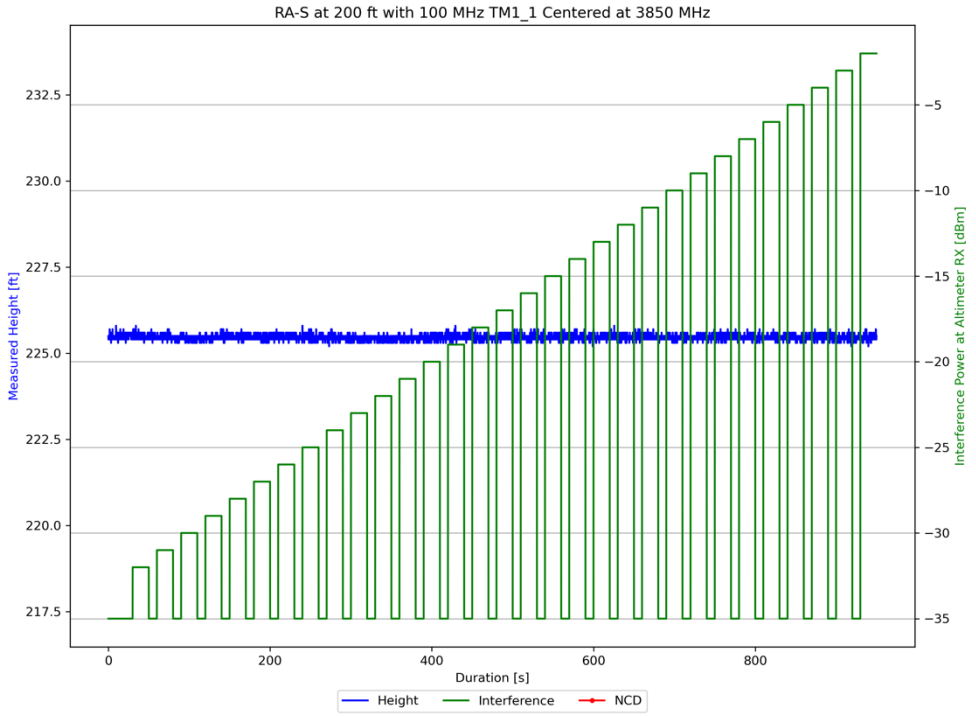

Figure 3-134: UC2 RA-S 200' AGL Time History with TM1.1 at 3850 MHz

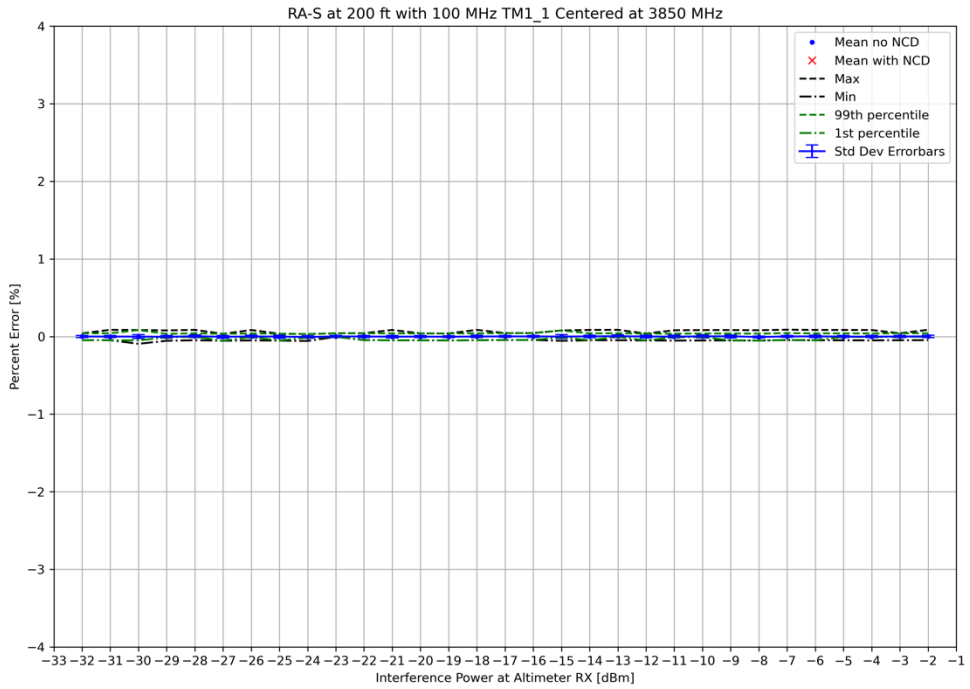

Figure 3-135: UC2 RA-S 200' AGL Statistics with TM1.1 at 3850 MHz

Center Frequency = 3930 MHz

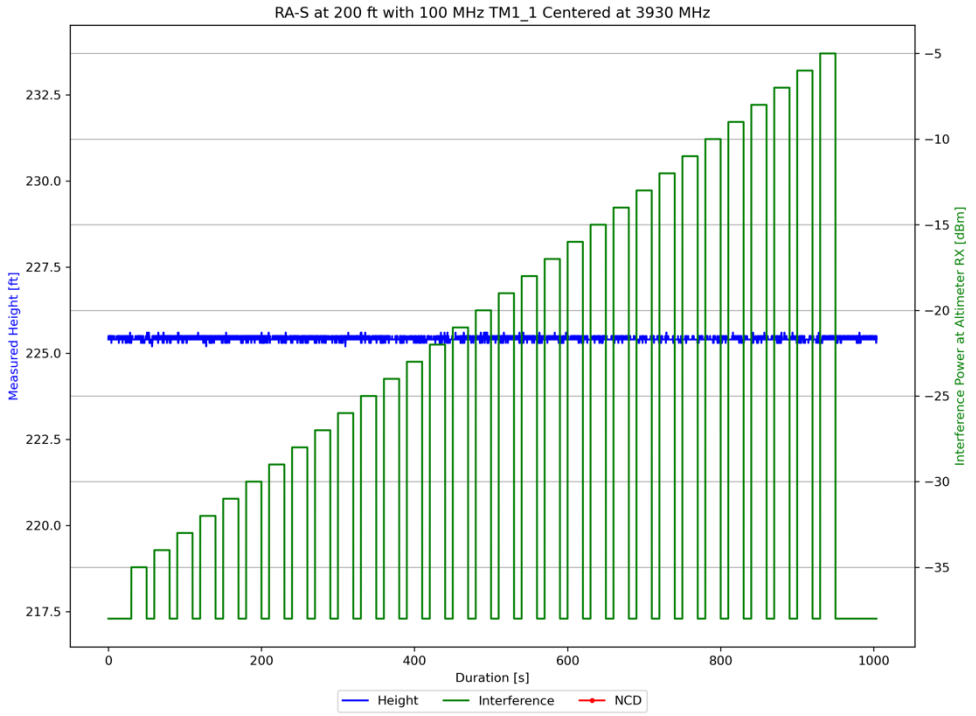

Figure 3-136: UC2 RA-S 200' AGL Time History with TM1.1 at 3930 MHz

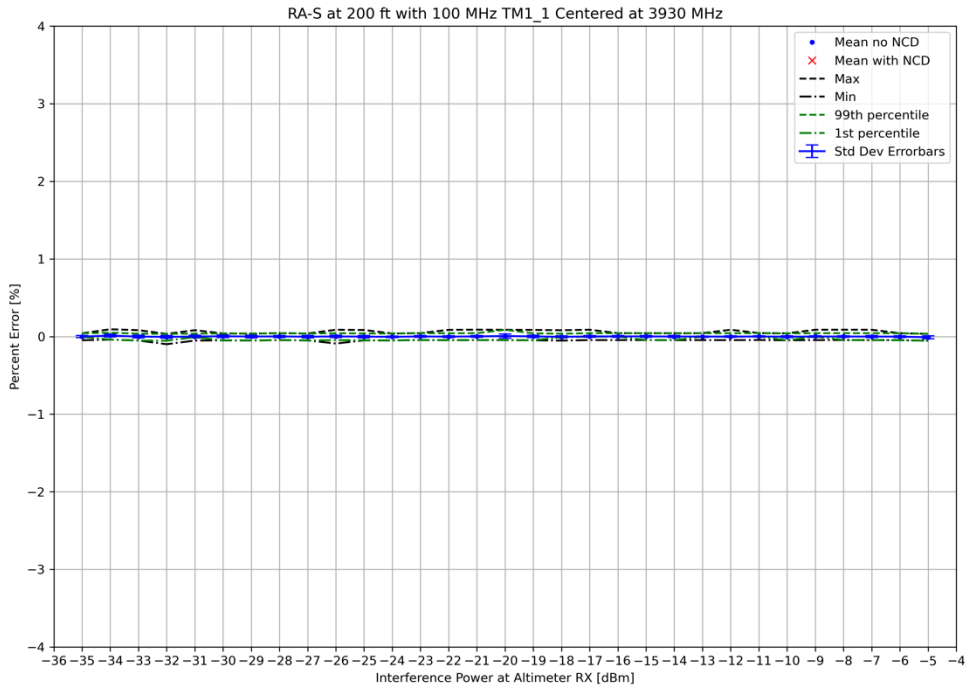

Figure 3-137: UC2 RA-S 200' AGL Statistics with TM1.1 at 3930 MHz

3.3.1.5 Altimeter V

Table 3-28: UC2 RA-V 200' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-138	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-139 Figure 3-140	Mean error first exceeds the ±0.5% criterion threshold near -50 dBm. 99th percentile measured height is greater than the +2% criterion threshold near -44 dBm. An NCD occurs near -41 dBm.
3850 MHz	Time History Figure 3-141	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-142 Figure 3-143	Mean error first exceeds the ±0.5% criterion threshold near -40 dBm. 1st percentile measured height is less than the -2% criterion threshold near -39 dBm. 99th percentile measured height is greater than the +2% criterion threshold near -35 dBm. An NCD occurs near -34 dBm.
3930 MHz	Time History Figure 3-144	Shows magnitude of change in measured height over time for increasing interference power levels. The plot shows that the RA was still recovering from the previous power sweep (CF = 3850 MHz) when this power sweep (CF = 3930 MHz) was initiated, as indicated by the spike in the measured height near t=0. These data can be excluded from the statistical analysis.
	Statistics Figure 3-145 Figure 3-146	Mean error first exceeds the ±0.5% criterion threshold at -42 dBm. 99th percentile measured height is greater than the +2% criterion threshold at -38 dBm. An NCD occurs at -36 dBm. 1st percentile measured height is less than the -2% criterion threshold at -35 dBm.

Center Frequency = 3750 MHz

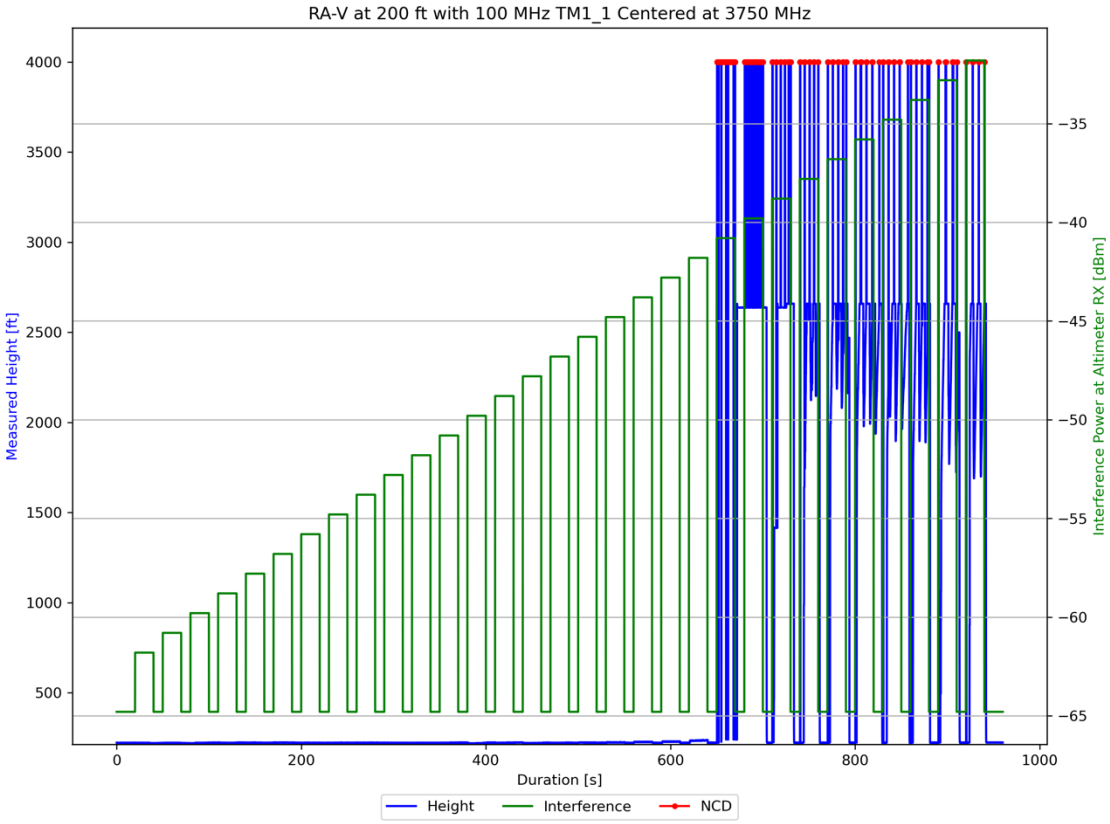

Figure 3-138: UC2 RA-V 200' AGL Time History with TM1.1 at 3750 MHz

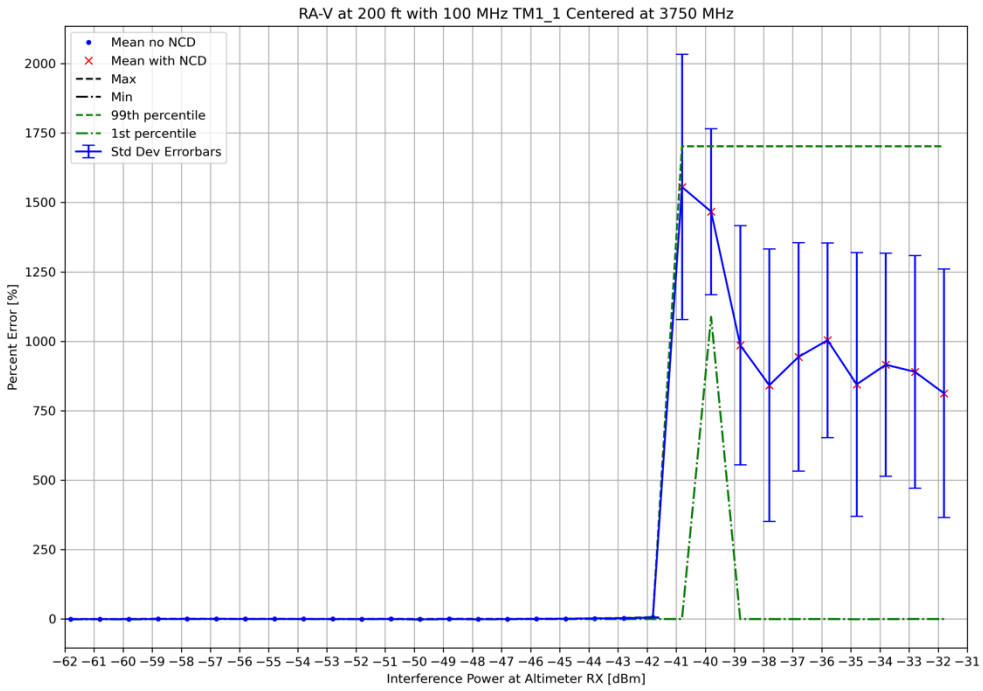

Figure 3-139: UC2 RA-V 200' AGL Statistics with TM1.1 at 3750 MHz – Zoomed Out

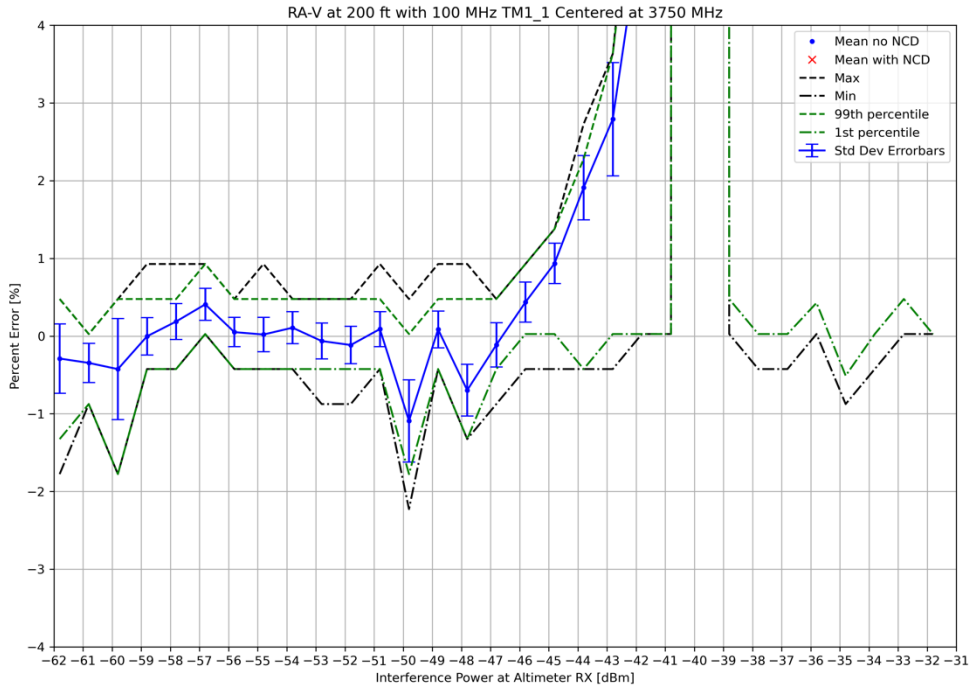

Figure 3-140: UC2 RA-V 200' AGL Statistics with TM1.1 at 3750 MHz – Zoomed In

Center Frequency = 3850 MHz

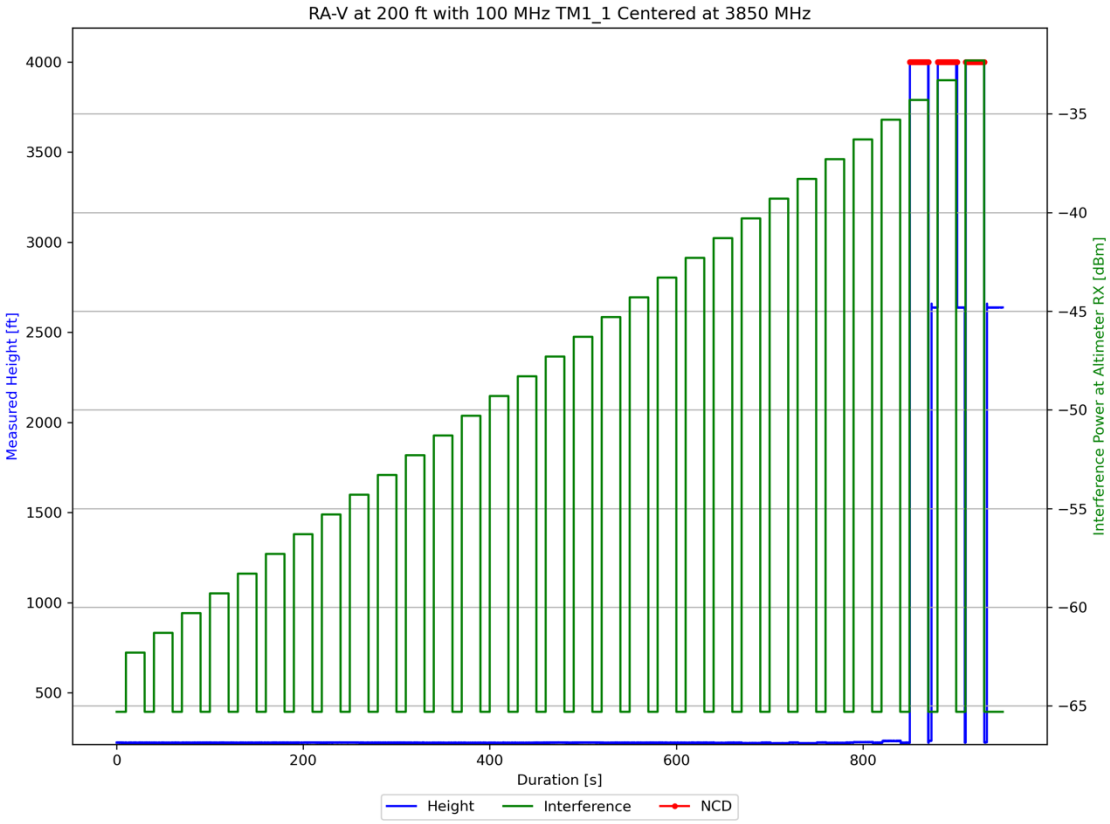

Figure 3-141: UC2 RA-V 200' AGL Time History with TM1.1 at 3850 MHz

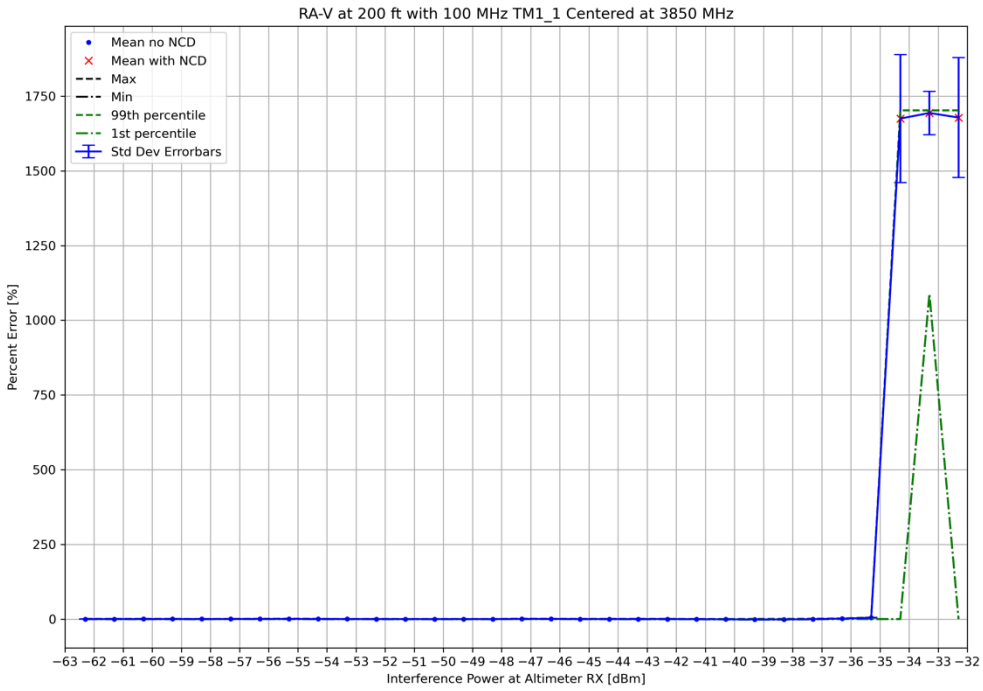

Figure 3-142: UC2 RA-V 200' AGL Statistics with TM1.1 at 3850 MHz – Zoomed Out

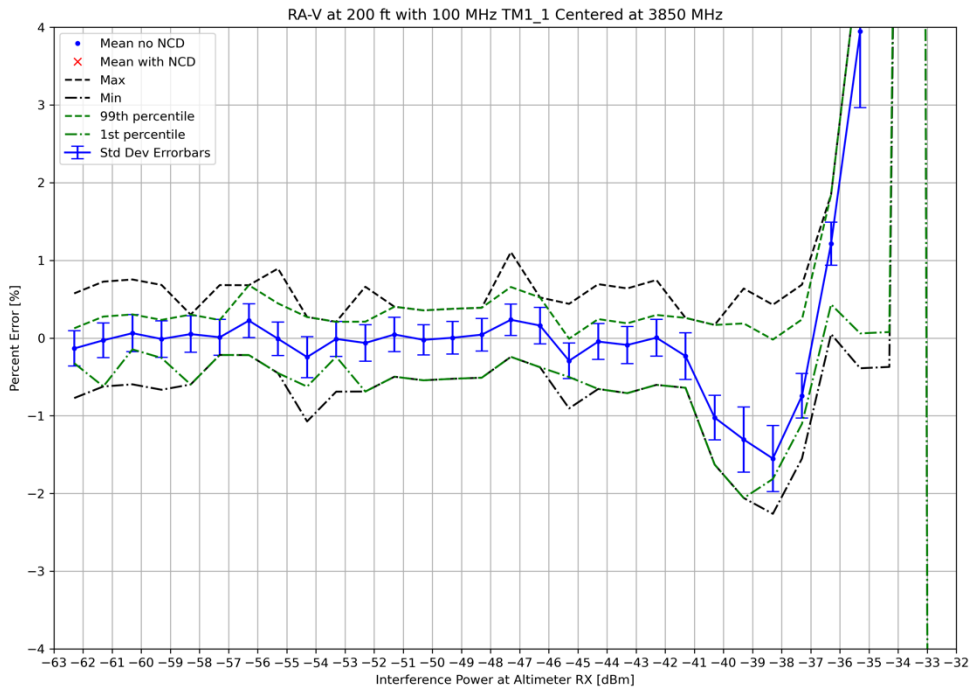

Figure 3-143: UC2 RA-V 200' AGL Statistics with TM1.1 at 3850 MHz – Zoomed In

Center Frequency = 3930 MHz

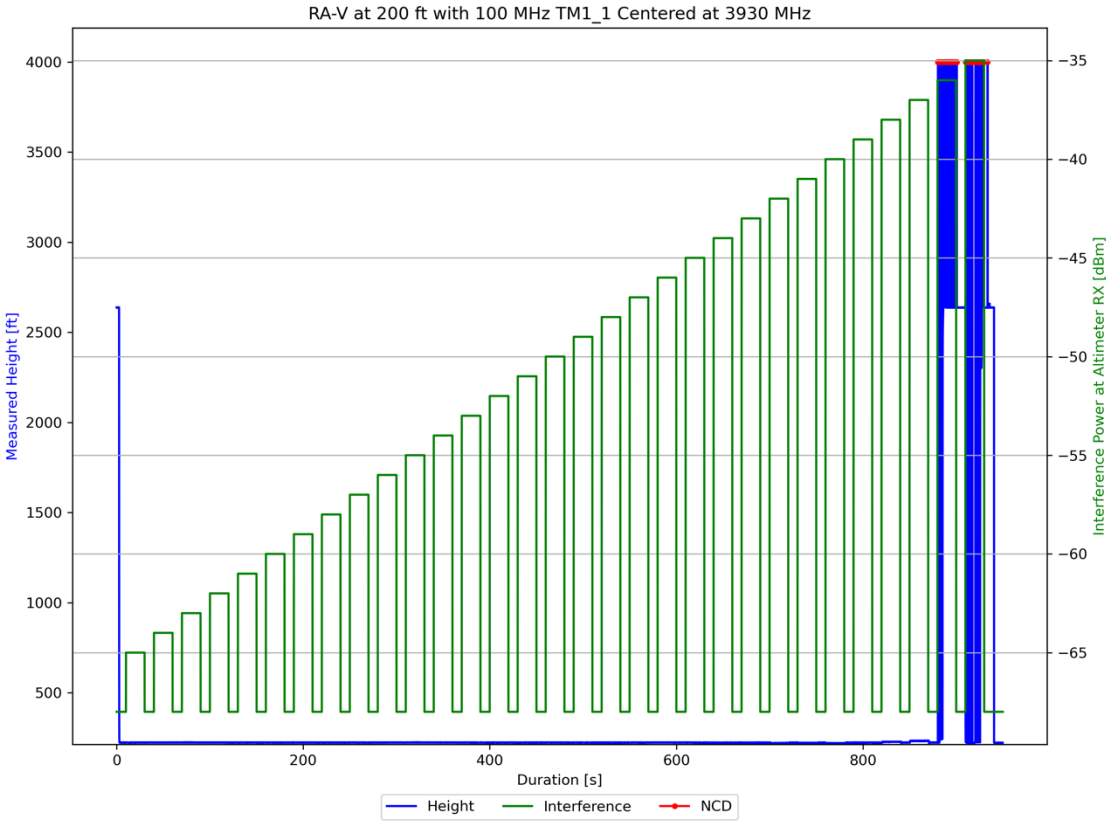

Figure 3-144: UC2 RA-V 200' AGL Time History with TM1.1 at 3930 MHz

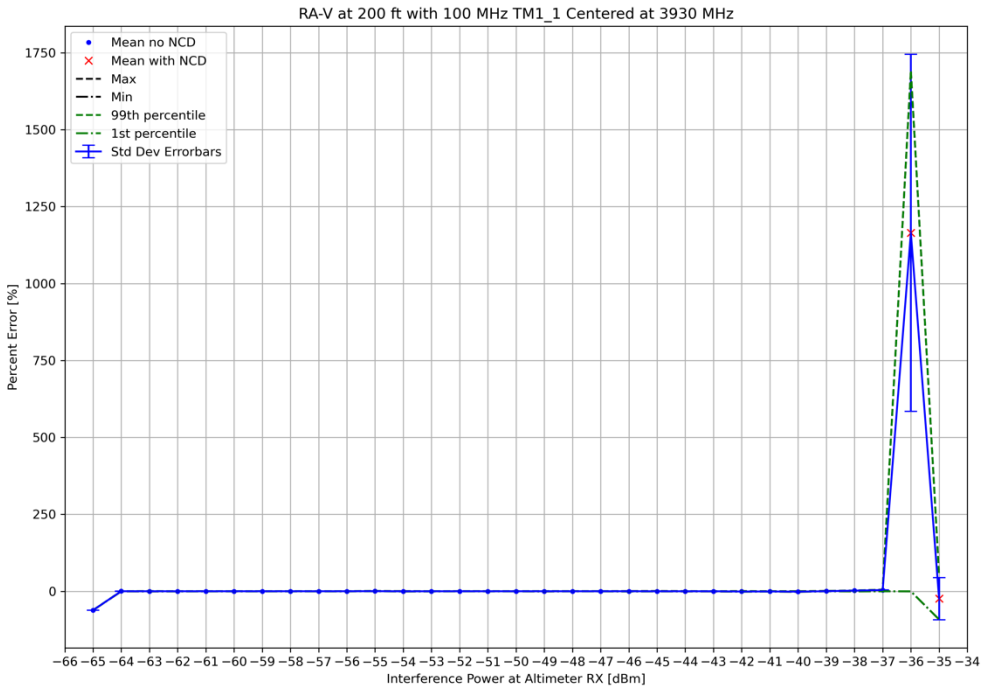

Figure 3-145: UC2 RA-V 200' AGL Statistics with TM1.1 at 3930 MHz – Zoomed Out

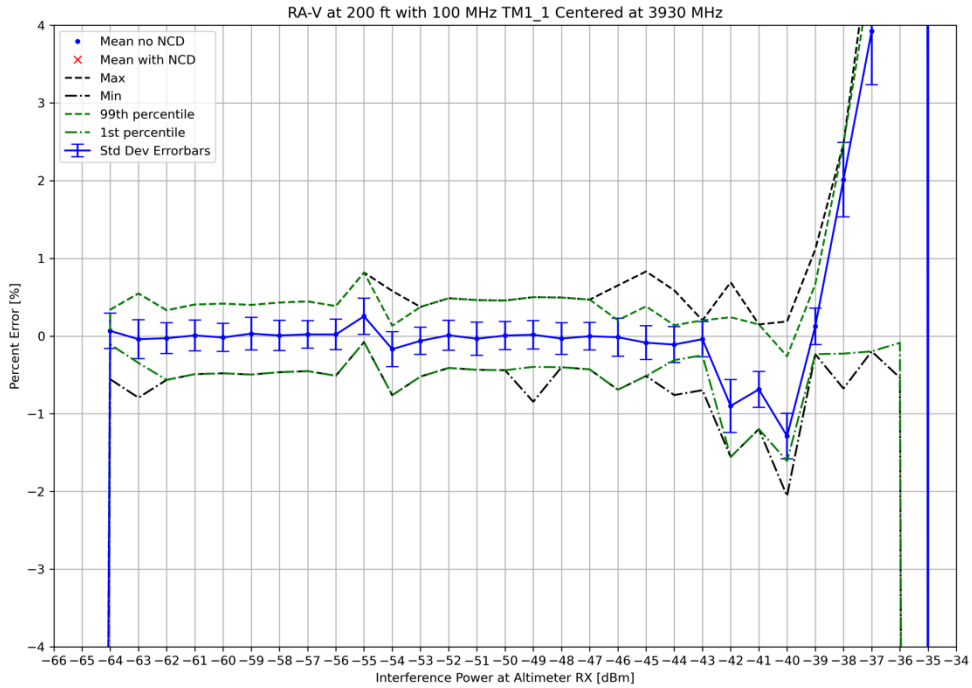

Figure 3-146: UC2 RA-V 200' AGL Statistics with TM1.1 at 3930 MHz – Zoomed In